In re Patent Application of: Junji Sato et al.

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For: ROTOR OF SMALL-SIZED MOTOR

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TRANSLATOR'S DECLARATION

Honorable Commissioner of Patents & Trademarks
Washington, D.C. 20231

Sir:

I, Nobuo Hamamoto , residing at c/o A. AOKI, ISHIDA & ASSOCIATES, Toranomon 37 Mori Bldg., 3-5-1, Toranomon Minato-ku, Tokyo 105-8423, Japan declare the following:

(1) That I know well both the Japanese and English languages;

(2) That I translated Japanese Patent Application No. 10-113043 , filed April 23, 1998 , from the Japanese language to the English language;

(3) That the attached English translation is a true and correct translation of the aforesaid Japanese Patent Application No. 10-113043 to the best of my knowledge and belief; and

(4) That all statements made of my own knowledge are true and that all statements made on information and belief are believed to be true, and further that these statements are made with the knowledge that willful false statements and the like are punishable by fine or imprisonment, or both, under 18 U.S.C. 1001, and that such false statements may jeopardize the validity of the application or any patent issuing thereon.

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Date

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[TITLE OF THE INVENTION] ROTOR FOR ELECTRONIC TIMEPIECES AND METHOD OF PRODUCING THE SAME

[NUMBER OF CLAIMS] 16

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[Name of Article]	Specification	1
[Name of Article]	Drawing	1
[Name of Article]	Abstract	1

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[NAME OF DOCUMENT] SPECIFICATION

[TITLE OF THE INVENTION] ROTOR FOR ELECTRONIC TIMEPIECES AND METHOD OF PRODUCING THE SAME

[SCOPE OF CLAIMS FOR PATENT]

[CLAIM 1] A rotor for an electronic timepiece obtained by press-joining a rotor shaft, having a pinion and a shaft formed integrally therewith, into a cylindrical rotor magnet of a rare earth bonded magnet having a hollow portion at a central portion thereof and plated with a metallic film, characterized in that the press-in length and the size of press-in margin are so adjusted that the rotor magnet is not cracked when it is joined to the rotor shaft while securing the rotor shaft with a force greater than the force required for the rotor shaft for an electronic timepiece.

[CLAIM 2] A rotor for an electronic timepiece according to claim 1, wherein the press-in length t is in a range of $T/5 \leqq t \leqq T/2$ relative to the height of the rotor magnet plated with a metallic film, the size of the press-in margin is in a range of not smaller than 5 μm but not larger than 30 μm, and the force of securing the rotor shaft is not smaller than 0.2 kgf.

[CLAIM 3] A rotor for an electronic timepiece according to claim 1 or 2, wherein the metallic film plated on the rare earth bonded magnet is an electroless-plated film.

[CLAIM 4] A rotor for an electronic timepiece according to claim 1, 2 or 3, wherein the metallic film plated on the rare earth bonded magnet is at least one of an electroless-plated Ni-P film, an electroless-plated Ni-B film or an electroless-plated Ni-P-W film.

[CLAIM 5] A rotor for an electronic timepiece according to claim 1, 2, 3 or 4, wherein the metallic film that is plated has a thickness of not smaller than 10 μm.

[CLAIM 6] A rotor for an electronic timepiece according to claim 1 or 2, wherein the metallic film plated on the rare

earth bonded magnet comprises an electroless plating as an underlying plated film and an electroplating as an upper plated film.

[CLAIM 7] A rotor for an electronic timepiece according to claim 1, 2 or 6, wherein the metallic film plated on the rare earth bonded magnet comprises at least one of an electroless-plated Ni-P film, an electroless-plated Ni-B film or an electroless-plated Ni-P-W film as an underlying plated film, and an electroplated Ni film as an upper plated film.

[CLAIM 8] A rotor for an electronic timepiece according to claim 1, 2, 6 or 7, wherein the metallic film that is plated comprises an underlying plated film which is an electroless plating having a thickness of not smaller than 0.5 μm but not larger than 2 μm and an upper plated film which is an electroplating having a thickness of not smaller than 3 μm.

[CLAIM 9] A method of producing a rotor for an electronic timepiece by press-joining a rotor shaft, having a pinion and a shaft formed integrally therewith, into a cylindrical rotor magnet of a rare earth bonded magnet having a hollow portion at a central portion thereof and plated with a metallic film, characterized in that the press-in length and the size of press-in margin are so adjusted that the rotor magnet is not cracked when it is joined to the rotor shaft while securing the rotor shaft with a force greater than the force required for the rotor shaft for an electronic timepiece.

[CLAIM 10] A method of producing a rotor for an electronic timepiece according to claim 9, wherein the press-in length t is in a range of $T/5 \leqq t \leqq T/2$ relative to the height of the rotor magnet plated with a metallic film, the size of the press-in margin is in a range of not smaller than 5 μm but not larger than 30 μm, and the force of securing the rotor shaft is not smaller than 0.2 kgf.

[CLAIM 11] A method of producing a rotor for an electronic timepiece according to claim 9 or 10, wherein the

rare earth bonded magnet is plated with a metal to adjust the size of the press-in margin by varying the thickness of the film.

[CLAIM 12] A method of producing a rotor for an electronic timepiece according to claim 9, 10 or 11, wherein the rare earth bonded magnet is impregnated with an adhesive in vacuum and, thereafter, is plated with at least one metal among an electroless-plated Ni-P, an electroless-plated Ni-B or an electroless-plated Ni-P-W.

[CLAIM 13] A method of producing a rotor for an electronic timepiece according to claim 9, 10, 11 or 12, wherein the metallic film that is plated has a thickness of not smaller than 10 μm.

[CLAIM 14] A method of producing a rotor for an electronic timepiece according to claim 9, 10 or 11, wherein the metallic film plated on the rare earth bonded magnet comprises an electroless plating as an underlying plated film and an electroplating as an upper plated film.

[CLAIM 15] A method of producing a rotor for an electronic timepiece according to claim 9, 10, 11 or 14, wherein the rare earth bonded magnet is impregnated with an adhesive in a vacuum and, thereafter, is plated with at least one of an electroless-plated Ni-P film, an electroless-plated Ni-B film or an electroless-plated Ni-P-W film as an underlying plated film and with an electroplated Ni film as an upper plated film.

[CLAIM 16] A method of producing a rotor for an electronic timepiece according to claim 9, 10, 11, 14 or 15, wherein the metallic film that is plated comprises an underlying plated film which is an electroless plating having a thickness of not smaller than 0.5 μm but not larger than 2 μm and an upper plated film which is an electroplating having a thickness of not smaller than 3 μm.

[DETAILED DESCRIPTION OF THE INVENTION]

[0001]

[Technical Field to which the Invention Belongs]

The present invention relates to a rotor for electronic timepieces in a converter used in electronic timepieces and to a method of producing the same.

[0002]

[Prior Art]

The present invention relates to a structure for securing a rotor shaft of a rotor to a rotor magnet in a converter used for electronic timepieces, and to a method of producing the same.

[0003]

The rotor shaft and the rotor magnet have heretofore been joined together by methods such as press-in, adhesion or the like. Among them, the junction based on the press-in by using a bonded magnet of a low cost offers such advantages as mass production and production at low cost.

[0004]

However, the junction based on a simple press-in is accompanied by a probability of causing the rotor magnet to be cracked at the time of press-in.

[0005]

One of the methods for solving this problem has been proposed in Japanese Examined Utility Model Publication (Kokoku) No. 54-71610. This will now be described with reference to Figs. 3 and 4.

[0006]

Fig. 3 is a sectional view of a rotor for electronic timepieces according to a prior art, and Fig. 4 is a sectional view along A-A' in Fig. 3. In Fig. 4, reference numeral 31 denotes a rotor magnet which is a rare earth sintered magnet, and 32 is a rotor shaft on which a pinion is formed integrally therewith. In Fig. 4, the outer periphery of the rotor shaft 32 on which the pinion is integrally formed is partly cut to assume an irregular shape.

[0007]

Referring to Fig. 3, the rotor shaft 32 is pushed into the hollow portion of the rotor magnet 31 from the lower side toward the upper side on the surface of the paper in Fig. 3, and is driven so as to come in contact with the whole inner peripheral length of the rotor magnet 31. Thus, the rotor shaft 32 is press-inserted in a manner that the outer peripheral surface of the rotor shaft 32 is in contact with the inner peripheral surface of the rotor magnet 31 in a discrete manner and is, thus, joined to the rotor magnet 31 while preventing the rotor magnet from being cracked at the time of press-in.

[0008]

[Problems to be Solved by the Invention]

When the rotor magnet is a bonded magnet, however, the strength is small and a large press-in margin cannot be obtained, resulting in an increased probability of cracking and making it difficult to accomplish a stable junction. Therefore, it has been urged to find a junction method capable of accomplishing the junction without causing the rotor magnet to be cracked at the time of junction yet maintaining a sufficiently large force for securing the rotor shaft.

[0009]

As described above, finding a method to join the rotor shaft to a bonded magnet, that is produced at a lower cost than that of the sintered magnet yet based on a simple press-in system, is important for realizing a rotor at a low cost.

[Object of the Invention]

It is an object of the present invention to provide a structure for securing a rotor shaft to a rotor magnet without causing the rotor magnet to be cracked at the time of junction, even when using a bonded magnet, yet maintaining a sufficient force for securing the rotor shaft, as a result of solving the above problem.

[0010]

[Means for Solving the Problems]

In order to accomplish the above object, the rotor for

electronic timepieces of the invention employs the constitutions as described below.

[0011]

Namely, a rotor for an electronic timepiece obtained by press-joining a rotor shaft having a pinion and a shaft formed integrally therewith into a cylindrical rotor magnet of a rare earth bonded magnet having a hollow portion at a central portion thereof and plated with a metallic film, characterized in that the press-in length and the size of press-in margin are so adjusted that the rotor magnet is not cracked when it is joined to the rotor shaft while securing the rotor shaft with a force greater than the force required for the rotor shaft for an electronic timepiece.

[0012]

A rotor for an electronic timepiece described in claim 2 has the constitution described in claim 1, wherein the press-in length t is in a range of $T/5 \leqq t \leqq T/2$ relative to the height of the rotor magnet plated with a film, the size of the press-in margin is in a range of not smaller than 5 µm but not larger than 30 µm, and the force of securing the rotor shaft is not smaller than 0.2 kgf.

[0013]

A rotor for an electronic timepiece described in claim 3 has the constitution described in claim 1 or 2, wherein the metallic film plated on the rare earth bonded magnet is a non-electrolytically plated film (or an electroless plating).

[0014]

A rotor for an electronic timepiece described in claim 4 has the constitution described in claim 1, 2 or 3, wherein the metallic film plated on the rare earth bonded magnet is at least one of a non-electrolytically plated Ni-P film, a non-electrolytically plated Ni-B film or a non-electrolytically plated Ni-P-W film.

[0015]

A rotor for an electronic timepiece described in claim 5

has the constitution described in claim 1, 2, 3 or 4, wherein the metallic film that is plated has a thickness of not smaller than 10 μm.

[0016]

A rotor for an electronic timepiece described in claim 6 has the constitution described in claim 1 or 2, wherein the metallic film plated on the rare earth bonded magnet comprises a non-electrolytically plated film as an underlying plated layer and an electrically plated film (or an electroplating) as an upper plated film.

[0017]

A rotor for an electronic timepiece described in claim 7 has the constitution described in claim 1, 2 or 6, wherein the metallic film plated on the rare earth bonded magnet comprises at least one of a non-electrolytically plated Ni-P film, a non-electrolytically plated Ni-B film or a non-electrolytically plated Ni-P-W film as an underlying plated film and an electrically plated Ni film as an upper plated film.

[0018]

A rotor for an electronic timepiece described in claim 8 has the constitution described in claim 1, 2, 6 or 7, wherein the metallic film that is plated comprises an underlying plated film which is a non-electrolytically plated film having a thickness of not smaller than 0.5 μm but not larger than 2 μm and an upper plated film which is an electrically plated film having a thickness of not smaller than 3 μm.

[0019]

In order to achieve the above object, the method of producing a rotor for electronic timepieces of the invention employs the constitutions described below.

[0020]

Namely, a method of producing a rotor for an electronic timepiece by press-joining a rotor shaft having a pinion and a shaft formed integrally therewith into a cylindrical rotor

magnet of a rare earth bonded magnet having a hollow portion at a central portion thereof and plated with a metallic film, characterized in that the press-in length and the size of press-in margin are so adjusted that the rotor magnet is not cracked when it is joined to the rotor shaft while securing the rotor shaft with a force greater than the force required for the rotor shaft for an electronic timepiece.

[0021]

A method of producing a rotor for an electronic timepiece described in claim 10 has the constitution described in claim 9, wherein the press-in length t is in a range of $T/5 \leqq t \leqq T/2$ relative to the height of the rotor magnet plated with a film, the size of the press-in margin is in a range of not smaller than 5 μm but not larger than 30 μm, and the force of securing the rotor shaft is not smaller than 0.2 kgf.

[0022]

A method of producing a rotor for an electronic timepiece described in claim 11 has the constitution described in claim 9 or 10, wherein the rare earth bonded magnet is plated with a metal to adjust the size of the press-in margin by varying the thickness of the film.

[0023]

A method of producing a rotor for an electronic timepiece described in claim 12 has the constitution described in claim 9, 10 or 11, wherein the rare earth bonded magnet is impregnated with an adhesive in vacuum, and is plated with at least one metal among a non-electrolytic Ni-P, a non-electrolytic Ni-B or a non-electrolytic Ni-P-W.

[0024]

A method of producing a rotor for an electronic timepiece described in claim 13 has the constitution described in claim 9, 10, 11 or 12, wherein the metallic film that is plated has a thickness of not smaller than 10 μm.

[0025]

A method of producing a rotor for an electronic timepiece

described in claim 14 has the constitution described in claim 9, 10 or 11, wherein the metallic film plated on the rare earth bonded magnet comprises a non-electrolytically plated film as an underlying plated layer and an electrically plated film as an upper plated film.

[0026]

A method of producing a rotor for an electronic timepiece described in claim 15 has the constitution described in claim 9, 10, 11 or 14, wherein the rare earth bonded magnet is impregnated with an adhesive in vacuum, and is plated with at least one of a non-electrolytic Ni-P film, a non-electrolytic Ni-B film or a non-electrolytic Ni-P-W film as an underlying plated film and with an electrically plated Ni film as an upper plated film.

[0027]

A method of producing a rotor for an electronic timepiece described in claim 16 has the constitution described in claim 9, 10, 11, 14 or 15, wherein the metallic film that is plated comprises an underlying plated film which is a non-electrolytically plated film having a thickness of not smaller than 0.5 μm but not larger than 2 μm and an upper plated film which is an electrically plated film having a thickness of not smaller than 3 μm.

[0028]

Namely, the invention is concerned with a method of joining a rotor shaft having a pinion and a shaft formed integrally therewith into a cylindrical rotor magnet of a rare earth bonded magnet, wherein the press-in length and the press-in margin are so adjusted that the rotor magnet is not cracked while obtaining a securing force which is greater than a specified value.

[0029]

Here, the press-in portion and the press-in length have the following meanings. That is, the press-in portion is the one where the rotor shaft 12 and the rotor magnet 11 are in contact with each other in the hollow portion of the rotor

magnet in a state where the rotor shaft 12 is in contact with the rotor magnet 11, and the press-in length is the length of the above portion, i.e., of the portion denoted by a sign t in Fig. 1.

[0030]

Referring to Fig. 1, further, the inner diameter of the rotor magnet after coated with a plated film is denoted by b, the outer diameter of the press-in portion of the rotor shaft is denoted by a (a > b), and a-b is regarded to be the press-in margin. Here, the specified securing force is the one for securing the rotor shaft of an electronic timepiece after pressed in without causing problem from the standpoint of production and function, and is selected to be 0.2 kgf, here. The securing force, here, is a load required for removing the rotor shaft 12 from the rotor magnet 11 by securing the rotor magnet 11 to the rotor shaft 12 and pushing the rotor shaft 12 upward from the lower side in the drawing. The force for securing the rotor shaft in Fig. 2 can be similarly defined.

[0031]

Described below are the reasons for limiting the press-in length and the press-in margin as stated in claims. Namely, when the rotor shaft is pressed into the rotor magnet while varying the press-in length and the press-in margin and when the destruction testing of the rotor magnet is conducted, it is discovered that the above problem could be solved within limited ranges of the press-in lengths and press-in margins.

[0032]

This will be concretely described with reference to Fig. 1. Fig. 1 is a sectional view of before and after the rotor shaft 12 is joined to the rotor magnet 11 according to the invention. The rotor magnet 11 is a rare earth bonded magnet having a metallic plated film 13. The shape of the rotor shaft is so changed that the press-in length t lies in a range $T/5 \leqq t \leqq T/2$ relative to the height T of the rotor magnet that is plated with a film as described in claim 2. That is, when t is smaller than T/t, the rotor shaft tends to be tilted

irrespective of the size of the press-in margin, and the shaft tends to be deviated. When t is greater than T/2, on the other hand, the rotor magnet cracks, with a greater probability, due to press-in.

[0033]

Next, when the press-in margin is smaller than 5 μm, the securing force becomes smaller than 0.2 kgf. When the press-in margin is not smaller than 30 μm, it is probable that the rotor magnet may be cracked even when the press-in length is not larger than T/2. As described in claims, therefore, the press-in length and the press-in margin are limited to prevent the magnet from cracking while producing a practicable securing force.

[0034]

Next, in the invention as described in claims, the rare earth bonded magnet is impregnated with an adhesive in vacuum and is, then, plated with at least one metal of non-electrolytic Ni-P, non-electrolytic Ni-B or non-electrolytic Ni-P-W. As the adhesive, there can be preferably used a thermosetting adhesive such as an epoxy resin or a phenolic resin having a relatively large adhering strength and good workability, or an anaerobic adhesive.

[0035]

Here, the bonded magnet is impregnated with an adhesive in vacuum in order to increase the breaking strength, to reduce the brittleness and to increase the mechanical strength of the rotor magnet. Further, the metallic film is plated in order to increase the mechanical strength of the magnet itself and to prevent the magnetic powder from falling off in the step of junction. Upon being impregnated with the adhesive in vacuum and upon being plated with a metal as described above, the strength of the bonded magnet material and the toughness are improved, eliminating the cracking of the magnet at the time when the rotor shaft is pressed in. Either the impregnation with the adhesive in vacuum or the plating of a metal alone is not effective against the cracking of the

magnet at the time of press-in. This stems from a composite effect of improved breaking strength at the time of press-in owing to the metal plating and of improved toughness owing to intimate adhesion between the rotor magnet and the metal plating as a result of a smoothed rotor magnet surface impregnated with the adhesive.

[0036]

The thickness of plating is limited to be not smaller than 10 μm. This is because when the thickness of plating is smaller than 10 μm, an increased mechanical strength of the rotor magnet is not accomplished and the object of the invention is not achieved. It is, however, desired that the thickness of the plating is not greater than 30 μm from the standpoint of managing the steps.

[0037]

In the invention, next, the rare earth bonded magnet is impregnated with the adhesive in vacuum, and at least one of the non-electrolytic Ni-P film, non-electrolytic Ni-B film or non-electrolytic Ni-P-W is plated as an underlying plated film, and an electrically plated Ni film is formed as an upper plated film. The metallic plated film comprises the non-electrolytically plated film which is the underlying plated film having a thickness of not smaller than 0.5 μm but not larger than 2 μm, and the electroplated film which is the upper plated film having a thickness of not smaller than 3 μm.

[0038]

The lower plated layer is to impart electric conduction to the surface of the rare earth bonded magnet. Owing to intimate adhesion and high mechanical strength, the electroplated film which is the upper plated layer exhibits the same effect despite a thickness smaller than that of the non-electrolytically plated film, enabling the rotor for an electronic timepiece to be produced, owing to a stable junction, without causing the rotor magnet to be cracked.

[0039]

Here, the non-electrolytic plating is limited to Ni-P, Ni-B or Ni-P-W, and the electroplating is limited to the Ni electroplating because of the following fact discovered by the present inventors. That is, the breaking strength of the rotor magnet is little improved with a metal plating of a low hardness, which is relatively rich in spreading property, such as of Cu, Pd, Au, Sn or solder (Pb/Sn). Besides, the securing force is low after the rotor shaft is pressed in. On the other hand, the non-electrolytic plating of Ni-P, Ni-B or Ni-P-W and the Ni electroplating have relatively high hardness and high Young's moduli, and contribute to greatly increasing the breaking strength of the rotor magnet after plated. Besides, a stable and high securing force is obtained.

[0040]

For these reasons, the kinds of metals plated onto the rare earth bonded magnet are limited as described above.

[0041]

(Mode of Operation)

The present invention makes it possible to produce a rotor for an electronic timepiece by press-joining a rotor shaft having a pinion and a shaft formed integrally therewith into a cylindrical rotor magnet of a rare earth bonded magnet coated with a metallic plated film, the rotor shaft that is press-joined having a press-in length and a press-in margin that are so adjusted as will not to cause cracking at all and will produce a securing force which is not smaller than a predetermined value.

[0042]

[Mode of Carrying Out the Invention]

The rare earth bonded magnet of the present invention may be any one of the SmCo type, the NdFeB type or the SmFeN type. The adhesive for being impregnated in vacuum may be in a liquid form, and is, preferably, a thermosetting adhesive which is cheaply available, offers a large adhering force and good workability, such as an epoxy resin, a phenol resin or a polyurethane, or an anaerobic adhesive, having good

permeability and a low viscosity.

[0043]

It is an object of the present invention to provide a method of joining the rotor shaft to the rotor magnet which is a rare earth bonded magnet based on a simple press-in, and a rotor for an electronic timepiece produced by the above method. The above object is achieved by press-joining the rotor shaft to the rotor magnet which is a rare earth bonded magnet plated with a metal, the rotor shaft being adjusted for its press-in length and press-in margin.

[0044]

Concretely speaking, the object is achieved by the press-in junction by so adjusting the press-in length and press-in margin that the press-in length t is in a range of $T/5 \leqq t \leqq T/2$ relative to the height T of the rotor magnet plated with a film, that the press-in margin is not smaller than 5 μm but is not larger than 30μm and that the force for securing the rotor shaft is not smaller than 0.2 kgf. Here, the rare earth bonded magnet is impregnated with an epoxy resin in vacuum to increase its strength and toughness.

[0045]

As the metal plating, any one of non-electrolytic Ni-P, non-electrolytic Ni-B or non-electrolytic Ni-P-W is plated. As the underlying plated film, at least any one of non-electrolytic Ni-P, non-electrolytic Ni-B or non-electrolytic Ni-P-W is plated, and an Ni electroplated film is formed as an upper plated film. Due to the two-layer plated film structure, it is possible to provide a rotor for an electronic timepiece having improved stability against the cracking of the rotor magnet and an increased securing force.

The rotor shaft may have any shape in cross section. Therefore, the present invention can be put into practice irrespective of the shape of the rotor shaft such as a circular shape in cross section, an irregular shape as shown in Fig. 4 or any other shape.

[0046]

[Embodiments]

(Embodiment 1)

The invention will now be described by way of an embodiment. Fig. 1 is a sectional view illustrating a rotor for an electronic timepiece according to an embodiment of the present invention. Fig. 1(a) illustrates a rotor for an electronic timepiece after the rotor shaft is press-joined to the rotor magnet, and Fig. 1(b) illustrates the rotor magnet which is non-electrolytically plated with Ni-P before being joined. In Fig. 1, reference numeral 11 denotes a rotor magnet which is a rare earth anisotropic bonded magnet obtained by using a magnet powder of the Sm_2Co_{17} type and an epoxy resin as a binder, 12 denotes a rotor shaft made of a JIS SK4 material having a pinion integrally formed therewith, and 14 is a plated metal film which, in this embodiment, is a non-electrolytically plated Ni-P film. Further, a sign t denotes a press-in length, a denotes an outer diameter of the press-in portion of the rotor shaft, b denotes an inner diameter of the rotor magnet after the bonded magnet is plated, and (a-b) is a press-in margin.

[0047]

That is, the rotor shaft is press-joined into the hollow portion of the rotor magnet, the rotor shaft having the press-in portion of an outer diameter a which is larger than the inner diameter b of the plated magnet. As a result, the rotor magnet undergoes a deformation of a-b, i.e., by the size of the press-in margin, and the rotor shaft is joined to the rotor magnet.

[0048]

The rotor magnet used in this embodiment will now be described in detail. First, before being plated, it measures ϕ1250 μm (outer diameter) x ϕ350 μm (inner diameter) x 460 μm (thickness). The bonded magnet comprises an SmCo (2-17 type) magnetic powder having an average particle diameter of 10 μm and 3% by weight of an epoxy resin binder, and is produced

through compression molding in a magnetic field. Here, the average particle diameter of the magnetic powder is measured in compliance with the Fischer's method. The bonded magnet contains 20 to 40% by volume of voids which can be filled with the thermosetting liquid epoxy resin by vacuum impregnation method to enhance the mechanical strength and toughness. Next, the whole bonded magnet is non-electrolytically plated with a uniform Ni-P film having a thickness of 20 μm to further increase the strength. Then, the bonded magnet exhibits a ring compression strength of not smaller than 10 times as great as that before being plated. When the thickness of the plated film is uneven, the plating may be so conducted as to possess a thickness of at least 20μm, and the size of the inner diameter may be finished by using a dill of ϕ310 μm.

[0049]

Next, there are provided rotor shafts 12 having press-in lengths t shown in Fig. 1 of 10 μm, 30 μm, 50 μm, 100 μm, 200 μm, 250 μm and 300 μm as shown in Tables 1, 2 and 3, and having outer diameters a of the press-in portions of ϕ312 μm, ϕ315 μm, ϕ320 μm, ϕ330 μm, ϕ340 μm and ϕ345 μm relative to the press-in lengths t. Tables 1, 2 and 3 show the results of when the above rotor shafts 12 are press-joined to the above rotor magnets 11. When the press-in margin is smaller than 5 μm, a securing force of not smaller than 0.2 kgf necessary for the rotor for electronic timepieces is not obtained. When the press-in margin exceeds 30 μm, on the other hand, the rotor magnet is often cracked due to the press-in. When the press-in length is smaller than 100 μm, the shaft is deviated. When the press-in length exceeds 250 μm, the rotor magnet is cracked due to the press-in. It is, therefore, necessary that the press-in length is not smaller than 100 μm but is not larger than 250 μm, and the size of press-in margin is not

smaller than 5 μm but is not larger than 30 μm.

It is found that the magnet does not crack, the securing force becomes not smaller than 0.2 kgf and the shaft is not deviated within ranges of bold lines shown in Tables 1, 2 and 3. From these results, the press-in length and the press-in margin of the rotor shaft are selected to assume values which lie at the center in the above ranges as much as possible, so that the rotor shaft can be joined relying upon the simple press-in on a scale of mass production even by taking into consideration the unevenness of the outer diameter of the press-in portion of the rotor shaft.

Namely, in the case of this embodiment, the rotor magnet after plated has a height $T \fallingdotseq 460 + 20 \times 2 = 500$ μm. Accordingly, $T/5 = 100$ μm and $T/2 = 250$ μm. It is thus found that the magnet does not crack, the securing force becomes not smaller than 0.2 kgf and the shaft is not deviated when the press-in length t lies in a range $T/5 \leqq t \leqq T/2$.

[0050]

[Table 1]

(a) Securing force (unit; kgf)

t \ a-b	2	5	10	20	30	35
10	0.01	0.03	0.09	0.54	0.95	2.05
30	0.05	0.07	0.10	0.85	1.56	-
50	0.08	0.22	0.90	1.40	1.90	-
100	0.12	0.35	1.25	2.32	2.81	-
200	0.14	0.59	1.50	2.70	3.40	-
250	0.18	0.81	2.32	2.72	3.90	-
300	0.01	0.02	-	-	-	-

unit of t and (a-b); μm

-; smaller than 0.01

[0051]

[Table 2]

(b) Breaking of rotor magnets

a-b / t	2	5	10	20	30	35
10	O	O	O	O	O	O
30	O	O	O	O	O	x
50	O	O	O	O	O	x
100	O	O	O	O	O	x
200	O	O	O	O	O	x
250	O	O	O	O	O	x
300	x	x	x	x	x	x

O; not cracked x; cracked

[0052]

[Table 3]

(c) Deviation of rotor magnet shafts

a-b / t	2	5	10	20	30	35
10	x	x	x	x	x	x
30	x	x	x	x	x	-
50	x	x	x	x	x	-
100	O	O	O	O	O	-
200	O	O	O	O	O	-
250	O	O	O	O	O	-
300	-	-	-	-	-	-

O; shaft is not deviated x; shaft is deviated

-; could not be evaluated due to broken rotor magnet

[0053]

The object of the present invention can be achieved when the rotor magnet for electronic timepieces has an outer diameter of not smaller than ϕ800 μm but not larger than ϕ1500 μm, an inner diameter of not smaller than ϕ250 μm but not larger than ϕ500 μm, and a thickness of not smaller than 400 μm but not larger than 800 μm. Further, the object of the present invention can be achieved when the plated thickness is not smaller than 10 μm. When the thickness exceeds 30 μm, it becomes difficult to manage the thickness of the plated film. It is therefore desired that the thickness is not larger than 30 μm.

[0054]

That is, even when the sizes of the rotor magnet and the thickness of the plated layer are different from those of the case of this embodiment, the object of the invention can be achieved by adjusting the press-in length and the press-in margin to lie within ranges described in the claims provided they are lying within the above-mentioned ranges of sizes and thickness of the plated layer.

In this embodiment, further, the size of the press-in margin is adjusted by varying the outer diameter of the press-in portion of the rotor shaft. The size of the press-in margin, however, may be adjusted by varying the thickness of the film with which the rotor magnet is plated.

[0055]

The adhesive to be impregnated is a thermosetting adhesive which offers a relatively large adhering force and good workability, such as an epoxy resin, a phenol resin or a polyurethane, or an anaerobic adhesive, making it possible to obtain similar advantages.

[0056]

(Embodiment 2)

The invention will be described by way of an embodiment 2. Fig. 2 is a sectional view illustrating a rotor for an electronic timepiece according to another embodiment of the present invention. Fig. 2(a) illustrates a rotor for an electronic timepiece after the rotor shaft 22 is press-joined to the rotor magnet 21, and Fig. 2(b) illustrates the rotor magnet which is non-electrolytically plated with Ni-P and electrically plated with an Ni film before being joined. In Fig. 2, the rotor magnet 21 is a rare earth anisotropic bonded magnet obtained by using a magnet powder of the Sm_2Co_{17} type and an epoxy resin as a binder. The rotor shaft 22 has a pinion integrally formed therewith. In this embodiment, the lower metallic plated film 24 is a non-electrolytically plated Ni-P film. The upper metallic plated film 25 is an electrically plated Ni film. Further, a sign t denotes a

press-in length, a denotes an outer diameter of the press-in portion of the rotor shaft, b denotes an inner diameter of the rotor magnet after coated with the plating, and (a-b) is a press-in margin.

[0057]

The rotor magnet used in this embodiment will now be described in detail. First, before being plated, it measures ϕ1250 μm (outer diameter) x ϕ350 μm (inner diameter) x 488 μm (thickness). The bonded magnet comprises an SmCo (2-17 type) magnetic powder having an average particle diameter of 10 μm and 3% by weight of an epoxy resin binder, and is produced through a compression molding in a magnetic field. Here, the average particle diameter of the magnetic powder is measured in compliance with the Fischer's method. The bonded magnet contains 20 to 40% by volume of voids which can be filled with the thermosetting liquid epoxy resin by vacuum impregnation method to enhance the mechanical strength and toughness. Next, the bonded magnet is non-electrolytically plated with an Ni-P film having a thickness of 1 μm as an underlying plated film and is electrically plated with an Ni film having a thickness of 5 μm as an upper plated film, so as to possess a uniform thickness to further increase the strength. Then, the bonded magnet exhibits a ring compression strength of not smaller than 10 times as great as before being plated. When the thickness of the plated film is uneven, the plating may be so conducted as to possess a thickness of at least 6μm, and the size of the inner diameter may be finished by using a drill of ϕ338 μm.

[0058]

Next, there are provided rotor shafts 22 made of a JIS SK4 material having press-in lengths t shown in Fig. 2 of 10 μm, 30 μm, 50 μm, 100 μm, 200 μm, 250 μm and 300 μm as shown in Tables 4, 5 and 6, and having outer diameters a of the press-in portions of ϕ340 μm, ϕ343 μm, ϕ348 μm, ϕ358 μm, ϕ368

μm and φ373 μm relative to the press-in lengths t. Tables 4, 5 and 6 show the results of when the above rotor shafts are press-joined to the above rotor magnets. When the press-in margin is smaller than 5 μm, a securing force necessary for the electronic timepieces is not obtained. When the press-in margin exceeds 30 μm, the rotor magnet is often cracked due to the press-in. When the press-in length is smaller than 100 μm, the shaft is deviated. When the press-in length exceeds 250 μm, the rotor magnet is cracked due to the press-in. It is, therefore, necessary that the press-in length is not smaller than 100 μm but is not larger than 250 μm, and the size of press-in margin is not smaller than 5 μm but is not larger than 30 μm.

It is found that the magnet does not crack, the securing force becomes not smaller than 0.2 kgf and the shaft is not deviated within ranges of bold lines shown in Tables 4, 5 and 6. From these results, the press-in length and the press-in margin of the rotor shaft are selected to assume values which lie at the center in the above ranges as much as possible, so that the rotor shaft can be joined relying upon the simple press-in on a mass production scale even taking into consideration the unevenness of the outer diameter of the press-in portion of the rotor shaft.

Namely, in the case of this embodiment, the rotor magnet after plated has a height $T \fallingdotseq 488 + (1 + 5) \times 2 = 500$ μm. Accordingly, $T/5 = 100$ μm and $T/2 = 250$ μm. It is thus found that the magnet does not crack, the securing force is not smaller than 0.2 kgf and the shaft is not deviated when the press-in length t lies in a range $T/5 \leqq t \leqq T/2$.

[0059]

[Table 4]

(a) Securing force (unit; kgf)

a-b / t	2	5	10	20	30	35
10	0.02	0.05	0.11	0.64	0.99	2.29
30	0.06	0.09	0.13	0.95	1.86	-
50	0.09	0.25	0.93	1.40	2.03	-
100	0.12	0.39	1.45	2.42	2.91	-
200	0.15	0.67	1.60	2.90	3.60	-
250	0.19	0.91	2.52	2.92	3.99	-
300	0.02	-	-	-	-	-

unit of t and (a-b); μm

-; smaller than 0.01

[0060]

[Table 5]

(b) Breaking of rotor magnets

a-b / t	2	5	10	20	30	35
10	O	O	O	O	O	O
30	O	O	O	O	O	x
50	O	O	O	O	O	x
100	O	O	O	O	O	x
200	O	O	O	O	O	x
250	O	O	O	O	O	x
300	x	x	x	x	x	x

O; not cracked x; cracked

[0061]

[Table 6]

(c) Deviation of rotor magnet shafts

a-b / t	2	5	10	20	30	35
10	x	x	x	x	x	x
30	x	x	x	x	x	-
50	x	x	x	x	x	
100	O	O	O	O	O	
200	O	O	O	O	O	-
250	O	O	O	O	O	-
300	-	-	-	-	-	-

O; shaft is not deviated x; shaft is deviated

-; could not be evaluated due to broken rotor magnet

[0062]

The object of the present invention can be achieved when the rotor magnet for electronic timepieces has an outer diameter of not smaller than ϕ800 μm but not larger than ϕ1500 μm, an inner diameter of not smaller than ϕ250 μm but not larger than ϕ500 μm, and a thickness of not smaller than 400 μm but not larger than 800 μm. Further, the object of the present invention can be achieved when the plated thickness, which is the sum of the thicknesses of the two layers of the lower metallic plated film and the upper metallic plated film, is not smaller than 3 μm. In this embodiment, the result that nearly equals to the case of a single non-electrolytically plated Ni-P film having a thickness of 20 μm shown in Example 1 is exhibited when the total thickness of the two plated layers is 5 μm. Accordingly, the object of the present invention can be accomplished even when the plated film has a small thickness which is easy to control relying upon the constitution employed in this embodiment.

[0063]

The adhesive to be impregnated is a thermosetting adhesive which offers a relatively large adhering strength and good workability, such as an epoxy resin, a phenol resin or a polyurethane, or an anaerobic adhesive, making it possible to obtain similar advantages.

[0064]

[Effects of the Invention]

As described above, the invention provides a rotor for an electronic timepiece obtained by press-joining a rotor shaft having a pinion and a shaft formed integrally therewith into a cylindrical rotor magnet of a rare earth bonded magnet coated with a metallic plated film, wherein the press-in length and the size of press-in margin are adjusted.

[0065]

It is therefore possible to produce a rotor which does

not crack at all yet produces a securing force which is not smaller than a specified value.

[0066]

Namely, it is made possible to stably produce the rotor for electronic timepieces by joining the rotor shaft to the rotor magnet relying upon a simple press-in method and, hence, to provide a rotor for electronic timepieces at a low cost.

[BRIEF DESCRIPTION OF THE DRAWINGS]

[Fig. 1] is a sectional view of a rotor for an electronic timepiece according to an embodiment of the present invention.

[Fig. 2] is a sectional view of the rotor for an electronic timepiece according to another embodiment of the present invention.

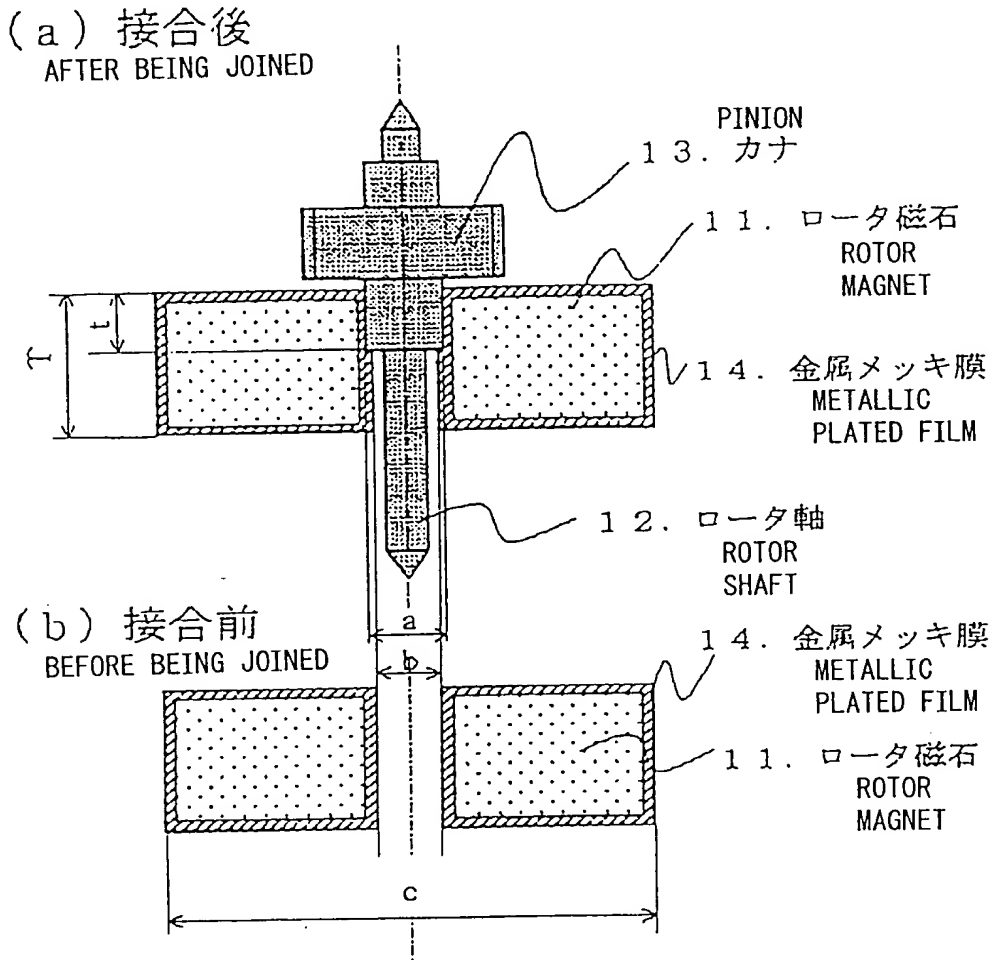
[Fig. 3] is a sectional view of a rotor for an electronic timepiece according to a prior art.

[Fig. 4] is a sectional view along A-A'.

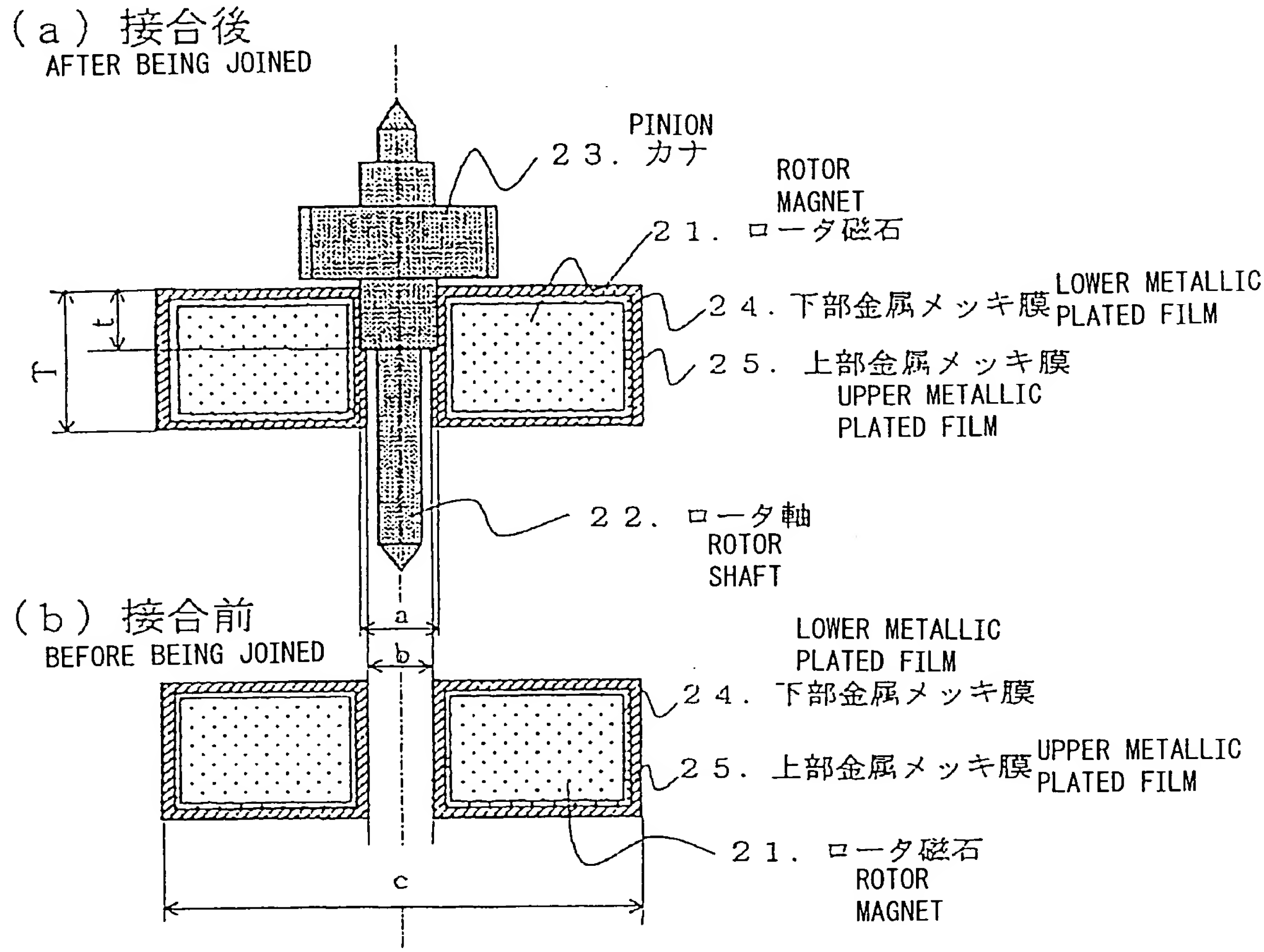
[Description of Reference Numerals]

11, 21, 31 - rotor magnets 12, 22, 32 - rotor shafts
13, 23, 33 - pinions14 - metallic plated film
24 - lower metallic plated film 25 - upper metallic plated film
T - height of rotor magnet after being plated
t - press-in length
a - outer diameter of press-in portion of rotor shaft
b - inner diameter of rotor magnet after being plated
c - outer diameter of rotor magnet after being plated

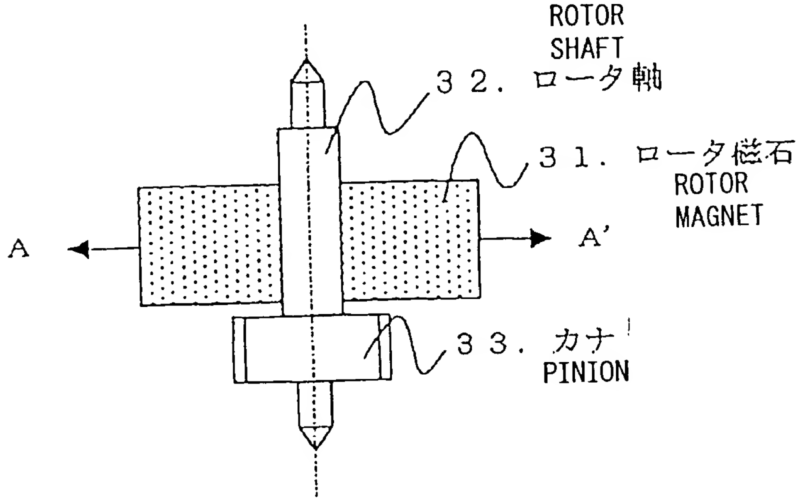
［書類名］　図面
[NAME OF DOCUMENT]　DRAWINGS
［図１］
[FIG. 1]



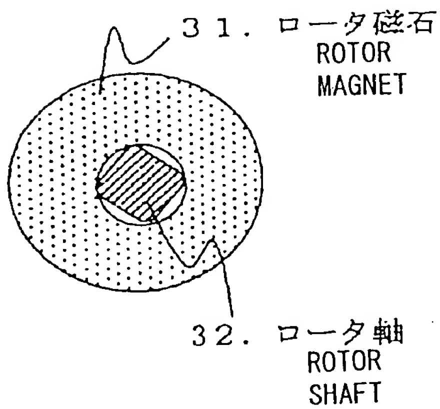
【図２】
[FIG. 2]


（ａ）接合後
AFTER BEING JOINED
PINION
２３．カナ
ROTOR
MAGNET
２１．ロータ磁石
LOWER METALLIC
PLATED FILM
２４．下部金属メッキ膜
２５．上部金属メッキ膜
UPPER METALLIC
PLATED FILM
t
T
２２．ロータ軸
ROTOR
SHAFT
a
（ｂ）接合前
BEFORE BEING JOINED
b
LOWER METALLIC
PLATED FILM
２４．下部金属メッキ膜
２５．上部金属メッキ膜
UPPER METALLIC
PLATED FILM
２１．ロータ磁石
ROTOR
MAGNET
c

【図３】
[FIG. 3]



【図４】
[FIG. 4]



[NAME OF DOCUMENT] ABSTRACT

[Abstract]

[Problem] A method of press-joining a rotor shaft, having a pinion and a shaft formed integrally therewith, into a cylindrical rotor magnet of a rare earth bonded magnet, having a hollow portion at a central portion thereof and plated with a metallic film, to produce a rotor for an electronic timepiece without causing the rotor magnet to be cracked yet obtaining a securing force which is not smaller than a specified value.

[Means for Solution] The press-in length and the size of press-in margin are so adjusted that the rotor magnet is not cracked when it is joined to the rotor shaft while securing the rotor shaft with a force greater than the force required for the rotor shaft of electronic timepieces. The rotor magnet is a rare earth bonded magnet impregnated with an epoxy resin in vacuum, and is plated with a single non-electrolytic Ni-P layer or with two layers of the non-electrolytic Ni-P layer and an electrically plated Ni layer to improve the strength.

[Selected Drawing] Fig. 1

JUN 0 6 2003

In re Patent Application of: Junji Sato et al.

Serial No. 09/673,750
Filed: October 20, 2000
For: ROTOR OF SMALL-SIZED MOTOR

Examiner: GONZALEZ, JULIO C
Group Art Unit: 2834

TRANSLATOR'S DECLARATION

Honorable Commissioner of Patents & Trademarks
Washington, D.C. 20231

Sir:

I, Nobuo Hamamoto, residing at c/o A. AOKI, ISHIDA & ASSOCIATES, Toranomon 37 Mori Bldg., 3-5-1, Toranomon Minato-ku, Tokyo 105-8423, Japan declare the following:

(1) That I know well both the Japanese and English languages;

(2) That I translated Japanese Patent Application No. 10-249376, filed September 3, 1998, from the Japanese language to the English language;

(3) That the attached English translation is a true and correct translation of the aforesaid Japanese Patent Application No. 10-249376 to the best of my knowledge and belief; and

(4) That all statements made of my own knowledge are true and that all statements made on information and belief are believed to be true, and further that these statements are made with the knowledge that willful false statements and the like are punishable by fine or imprisonment, or both, under 18 U.S.C. 1001, and that such false statements may jeopardize the validity of the application or any patent issuing thereon.

June 2, 2003

Date

N. Hamamoto

Translator Nobuo Hamamoto

[NAME OF DOCUMENT] APPLICATION FOR PATENT

[REFERENCE NUMBER] P-24276

[DATE FILED] September 3, 1998

[DESTINATION] To Commissioner, Patent Office; Mr. Takeshi Isayama

[INTERNATIONAL PATENT CLASSIFICATION] H02K 1/28

[TITLE OF THE INVENTION] ROTOR FOR ELECTRONIC TIMEPIECES AND METHOD OF PRODUCING THE SAME

[NUMBER OF CLAIMS] 9

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[INDICATION OF FEES TO BE PAID]

[Registration Number for Prepayment]	003517
[Amount of Fee]	21000

[LIST OF ARTiCLES TO BE SUBMITTED]

[Name of Article]	Specification	1
[Name of Article]	Drawing	1
[Name of Article]	Abstract	1

[NEED FOR PROOF] Yes

[NAME OF DOCUMENT] SPECIFICATION

[TITLE OF THE INVENTION] ROTOR FOR ELECTRONIC TIMEPIECES AND METHOD OF PRODUCING THE SAME

[SCOPE OF CLAIMS FOR PATENT]

[CLAIM 1] A rotor for an electronic timepiece obtained by press-joining a rotor shaft, having a pinion and a shaft formed integrally therewith, into a cylindrical rotor magnet formed of a rare earth magnet having a hollow portion at a central portion thereof, characterized in that the inner periphery of the hollow portion of the rotor magnet includes a portion that is not in contact with the rotor shaft, and a space formed between this portion and the rotor shaft is filled with an adhesive.

[CLAIM 2] A rotor for an electronic timepiece obtained by press-joining a rotor shaft, having a pinion and a shaft formed integrally therewith, into a cylindrical rotor magnet formed of a rare earth magnet having a hollow portion at a central portion thereof, characterized in that a press-in length t is in a range of $T/5 \leqq t \leqq T/2$ relative to the height T of the rotor magnet, the inner periphery of the hollow portion of the rotor magnet includes a portion that is not in contact with the rotor shaft, and a space formed between this portion and the rotor shaft is filled with an adhesive.

[CLAIM 3] A rotor for an electronic timepiece according to claim 1 or 2, wherein the rotor magnet is a rare earth bonded magnet, and a metallic film is plated on, or an organic film is formed on, the surface of the rare earth bonded magnet.

[CLAIM 4] A rotor for an electronic timepiece according to claim 1, 2 or 3, wherein the adhesive is a thermosetting epoxy resin.

[CLAIM 5] A method of producing a rotor for an electronic timepiece obtained by press-joining a rotor shaft,

having a pinion and a shaft formed integrally therewith, into a cylindrical rotor magnet formed of a rare earth magnet having a hollow portion at a central portion thereof, comprising:

a first step of press-fitting the rotor shaft into the rotor magnet; and

a second step of filling a space with an adhesive, said space being formed between the rotor shaft and a portion of the inner periphery of the hollow portion of the rotor magnet that is not in contact with the rotor shaft.

[CLAIM 6] A method of producing a rotor for an electronic timepiece obtained by press-joining a rotor shaft, having a pinion and a shaft formed integrally therewith, into a cylindrical rotor magnet formed of a rare earth magnet having a hollow portion at a central portion thereof, comprising:

a first step of press-fitting the rotor shaft having a press-in length t which is in a range of $T/5 \leqq t \leqq T/2$ relative to the height T of the rotor magnet; and

a second step of filling a space with an adhesive, said space being formed between the rotor shaft and a portion of the inner periphery of the hollow portion of the rotor magnet that is not in contact with the rotor shaft.

[CLAIM 7] A method of producing a rotor for an electronic timepiece according to claim 5 or 6, wherein the adhesive is filled by a vacuum impregnation method.

[CLAIM 8] A method of producing a rotor for an electronic timepiece according to claim 5, 6 or 7, wherein the rotor magnet is a rare earth bonded magnet, and a metallic film is plated on, or an organic film is formed on, the surface of the rare earth bonded magnet.

[CLAIM 9] A method of producing a rotor for an electronic timepiece according to claim 5, 6, 7 or 8, wherein the adhesive is a thermosetting epoxy resin.

[DETAILED DESCRIPTION OF THE INVENTION]

[0001]

[Technical Field to which the Invention Belongs]

The present invention relates to a rotor for electronic timepieces in a converter used in electronic timepieces and to a method of producing the same.

[0002]

[Prior Art]

The present invention relates to a structure for securing a rotor shaft of a rotor to a rotor magnet in a converter used for electronic timepieces, and to a method of producing the same.

[0003]

The rotor shaft and the rotor magnet have heretofore been joined together by methods such as press-in, adhesion or the like.

[0004]

However, the junction based on a simple press-in is accompanied by a probability of causing the rotor magnet to be cracked at the time of press-in.

[0005]

One of the methods for solving this problem has been proposed in Japanese Examined Utility Model Publication (Kokoku) No. 54-71610. This will now be described with reference to Figs. 3 and 4.

[0006]

Fig. 3 is a sectional view of a rotor for electronic timepieces according to a prior art, and Fig. 4 is a sectional view along A-A' in Fig. 3. In Fig. 4, reference numeral 31 denotes a rotor magnet which is a rare earth sintered magnet, and 32 is a rotor shaft on which a pinion is formed integrally therewith. In Fig. 4, the outer periphery of the rotor shaft 32 on which the pinion is integrally formed is partly cut to possess an irregular shape.

[0007]

Referring to Fig. 3, the rotor shaft 32 is pushed into the hollow portion of the rotor magnet 31 from the lower side

toward the upper side on the surface of the paper in Fig. 3, and is driven so as to come in contact with the whole inner peripheral length of the rotor magnet 31. Thus, the rotor shaft 32 is press-inserted in a manner that the outer peripheral surface of the rotor shaft 32 is in contact with the inner peripheral surface of the rotor magnet 31 in a discrete manner and is, thus, joined to the rotor magnet 31 while preventing the rotor magnet from being cracked at the time of press-in.

[0008]

[Problems to be Solved by the Invention]

The press-junction taught in Japanese Examined Utility Model Publication (Kokoku) No. 54-71610 features a large securing force due to the local concentration of stress since the rotor shaft is of a polygonal shape. This, however, is accompanied by a problem in that the rotor magnet having a small strength may be cracked at the time of junction.

[0009]

In the case of the junction by using a solder or an adhesive, on the other hand, there does not occur the above-mentioned problem of the junction based on the press-in; i.e., no crack occurs at the time of junction, and a large securing force is obtained.

However, a junction over a very narrow portion of a diameter of from 0.3 to 0.5 mm permits the solder or the adhesive to be forced out. Therefore, this junction method cannot be adapted to mass production.

[0010]

There has further been proposed a junction method via a bush as taught in Japanese Examined Utility Model Publication (Kokoku) No. 56-71078 accompanied, however, by a problem of an increased number of parts.

[0011]

In producing the rotors for electronic timepieces, at present, the problem is how to produce a reliable rotor at a low cost. The present invention was accomplished in view of

these circumstances.

[0012]

[Object of the Invention]

It is an object of the present invention to provide a structure for securing a rotor shaft to a rotor magnet without causing the rotor magnet to be cracked at the time of junction yet maintaining a force sufficient for securing the rotor shaft, as a result of solving the above problem.

[0013]

[Means for Solving the Problems]

In order to accomplish the above object, the rotor for electronic timepieces of the invention employs the constitutions as described below.

[0014]

Namely, a rotor for an electronic timepiece obtained by press-joining a rotor shaft, having a pinion and a shaft formed integrally therewith, into a cylindrical rotor magnet formed of a rare earth magnet having a hollow portion at a central portion thereof, characterized in that the inner periphery of the hollow portion of the rotor magnet includes a portion that is not in contact with the rotor shaft, and a space formed between this portion and the rotor shaft is filled with an adhesive.

[0015]

A rotor for an electronic timepiece described in claim 2 is the one obtained by press-joining a rotor shaft, having a pinion and a shaft formed integrally therewith, into a cylindrical rotor magnet formed of a rare earth magnet having a hollow portion at a central portion thereof, characterized in that a press-in length t is in a range of $T/5 \leqq t \leqq T/2$ relative to the height T of the rotor magnet, the inner periphery of the hollow portion of the rotor magnet includes a portion that is not in contact with the rotor shaft, and a space formed between this portion and the rotor shaft is filled with an adhesive.

[0016]

A rotor for an electronic timepiece described in claim 3 has the constitution described in claim 1 or 2, wherein the rotor magnet is a rare earth bonded magnet, and a metallic film is plated on, or an organic film is formed on, the surface of the rare earth bonded magnet.

[0017]

A rotor for an electronic timepiece described in claim 4 has the constitution described in claim 1, 2 or 3, wherein the adhesive is a thermosetting epoxy resin.

[0018]

In order to achieve the above object, the method of producing a rotor for electronic timepieces of the invention employs the constitutions described below.

[0019]

Namely, a method of producing a rotor for an electronic timepiece obtained by press-joining a rotor shaft, having a pinion and a shaft formed integrally therewith, into a cylindrical rotor magnet formed of a rare earth magnet having a hollow portion at a central portion thereof, comprising:

a first step of press-fitting the rotor shaft into the rotor magnet; and

a second step of filling a space with an adhesive, said space being formed between the rotor shaft and a portion of the inner periphery of the hollow portion of the rotor magnet that is not in contact with the rotor shaft.

[0020]

A method of producing a rotor for an electronic timepiece described in claim 6 is the one for producing a rotor for an electronic timepiece obtained by press-joining a rotor shaft having a pinion and a shaft formed integrally therewith into a cylindrical rotor magnet formed of a rare earth magnet having a hollow portion at a central portion thereof, comprising:

a first step of press-fitting the rotor shaft having a press-in length t which is in a range of $T/5 \leqq t \leqq T/2$ relative to the height T of the rotor magnet; and

a second step of filling a space with an adhesive, said

space being formed between the rotor shaft and a portion of the inner periphery of the hollow portion of the rotor magnet that is not in contact with the rotor shaft.

[0021]

A method of producing a rotor for an electronic timepiece described in claim 7 has the constitution described in claim 5 or 6, wherein the adhesive is filled by a vacuum impregnation method.

[0022]

A method of producing a rotor for an electronic timepiece described in claim 8 has the constitution described in claim 5, 6 or 7, wherein the rotor magnet is a rare earth bonded magnet, and a metallic film is plated on, or an organic film is formed on, the surface of the rare earth bonded magnet.

[0023]

A method of producing a rotor for an electronic timepiece described in claim 9 has the constitution described in claim 5, 6, 7 or 8, wherein the adhesive is a thermosetting epoxy resin.

[0024]

Namely, the invention is concerned with a method of joining a rotor shaft, having a pinion and a shaft formed integrally therewith, into a cylindrical rotor magnet, comprising a first step of lightly press-fitting the rotor shaft to a degree of temporary attachment, and a second step of junction by infiltrating an adhesive into a gap between the rotor shaft and the rotor magnet by vacuum impregnation to obtain a practicable securing force without breaking the rotor magnet.

[0025]

The invention will now be concretely described with reference to Fig. 1. Fig. 1 is a sectional view of the invention before and after the rotor shaft 12 is joined to the rotor magnet 11.

Here, the press-in portion and the press-in length have the following meanings. That is, in Fig. 1, the press-in

portion is the one where the rotor shaft 12 and the rotor magnet 11 are in contact with each other in the hollow portion of the rotor magnet in a state where the rotor shaft 12 is in contact with the rotor magnet 11, and the press-in length is the length of the above portion, i.e., of the portion denoted by the letter t in Fig. 1.

[0026]

Further, the adhered portion stands for a portion where the rotor shaft 12 is not in contact with the rotor magnet 11 in the hollow portion in the rotor magnet in a state after the rotor shaft 12 is joined to the rotor magnet 11, and the length of the adhered portion stands for the length of the above portion. Namely, in Fig. 1, the portion denoted by a sign (T - t) represents the length of the adhered portion.

[0027]

Referring to Fig. 1, further, the inner diameter of the rotor magnet is denoted by b, the outer diameter of the press-in portion of the rotor shaft is denoted by a (a > b), and a-b is regarded to be the press-in margin. Further, the outer diameter of the adhered portion of the rotor shaft is denoted by c, and the outer diameter of the rotor magnet is denoted by d. The height of the rotor magnet is denoted by T. Referring, here, to Fig. 2, when the rotor magnet is plated with a metallic film or is coated with an organic film, the height T of the rotor magnet, the inner diameter b of the rotor magnet and the outer diameter d of the rotor magnet are, respectively, those of after the rotor magnet is plated with the metallic film or is coated with the organic film. Therefore, (b-c) represents the adhesion margin of a portion that is joined to the rotor shaft by adhesion or of a portion of the rotor magnet, in the direction of the inner diameter thereof, in the hollow portion of the rotor magnet.

[0028]

The specified securing force is the one for securing the rotor shaft of an electronic timepiece after press-joined without causing problem from the standpoint of production and

function, and is selected to be 0.2 kgf, here. The securing force, here, is a load required for removing the rotor shaft 12 from the rotor magnet 11 by securing the rotor magnet 11 to the rotor shaft 12 and, then, pushing the rotor shaft 12 upward from the lower side in the drawing. The force for securing the rotor shaft in Fig. 2 can be similarly defined.

[0029]

Described below are the joining steps. In the first step of press-fitting the rotor shaft into the rotor magnet, it is necessary that the rotor magnet is not broken, and the press-in length and the press-in margin with which the rotor magnet withstands the mechanical strength are determined by taking dispersions in the sizes into consideration. The rotor shaft may be secured with a force nearly equal to that of temporary attachment, and the press-in margin is desirably not larger than 5 μm to prevent the rotor magnet breaking.

[0030]

Further, described below are the reasons for limiting the press-in length as stated in claims. Namely, it was found that, with the rotor shaft being press-fitted into the rotor magnet in the step of the invention while varying the press-in length, the rotor shaft is deviated at the time of press-in when the press-in length t is $t < T/5$. When $t > 4T/5$, then, the adhesion margin is small, the adhering force due to the adhesion is small, and a securing force of not smaller than a specified value is not obtained.

[0031]

Next, in the second step of infiltrating the adhesive 14 into a gap between the rotor shaft and the rotor magnet by vacuum impregnation, the adhesive is infiltrated into a gap (length: T-t, adhesion margin: b-c) in a space in the rotor magnet to which the rotor shaft is temporarily attached in the first step to thereby obtain a stable securing force which is not smaller than the specified value. Here, it is desired that the adhesion margin (b-c) is not smaller than 2 μm in the gaps into where the adhesive infiltrates.

[0032]

The adhesive adhered by vacuum impregnation to the portions other than the gaps can be easily removed and washed away with an organic solvent while leaving the adhesive in the gaps, and the adhesive is completely prevented from staying in a state of being forced out. Further, the vacuum impregnation method makes it possible to batchwisely treat a number of articles at one time, making it possible to provide a rotor for an electronic timepiece at a low cost.

[0033]

When the rotor magnet is a rare earth bonded magnet having a relatively small mechanical strength, the surfaces are plated with a metallic film or are coated with an organic film to increase the mechanical strength, and a stable securing force is obtained based on the same junction method. It is desired that the metallic plated film is a non-electrolytically plated film such as of Ni-P or Ni-P-W and the organic film is a vacuum evaporated film such as of polyparaxylylene, or a spray-coated film of an epoxy resin, from the standpoint of production.

[0034]

Here, the adhesive is limited to a thermosetting epoxy resin from the standpoint of a strong adhering force and stable productivity. Namely, a long pot life is obtained at room temperature and the viscosity can be arbitrarily adjusted. It is desired here that the epoxy resin has a viscosity which is as low as possible and its pot life is as long as possible, at normal temperature, from the standpoint of working.

[0035]

(Mode of Operation)

The present invention is concerned with a method of joining a rotor shaft having a pinion and a shaft formed integrally therewith into a cylindrical rotor magnet, comprising:

a first step of lightly pressing the rotor shaft having a

press-in length smaller than the height of the rotor magnet into the rotor magnet to a degree of temporary attachment; and

a second step of filling a gap between the rotor shaft and the rotor magnet with an adhesive by vacuum impregnation in the hollow portion of the rotor magnet;

thus making it possible to provide a rotor magnet for an electronic timepiece at a low cost without, at all, causing the rotor magnet to be broken while realizing a stable securing force.

[0036]

In order to secure the rotor shaft, first, the rotor shaft is lightly pressed into the rotor magnet to a degree of temporary attachment. This light press-in does not cause any cracking.

Following the light press-in, the rotor shaft is finally joined to the rotor magnet by the above-mentioned method of adhesion. Accordingly, the rotor finally produced has no adhesive which may be left in the conventional junction by adhesion.

Besides, no new parts for junction, such as bush and the like, are used. Therefore, the number of parts can be decreased compared to the case of using parts such as bush and the like, and the rotor can be produced at a low cost.

[0037]

According to the present invention as described above, there are provided a structure for securing the rotor shaft to the rotor magnet without cracking the rotor magnet at the time of junction yet producing a sufficient force for securing the rotor shaft, and a method of producing the same, making it possible to produce a reliable rotor at a decreased cost.

[0038]

[Mode for Carrying Out the Invention]

According to the present invention, the object of the invention is accomplished by adjusting the length of the press-in portion as stated in the claims, by pressing the rotor shaft into the cylindrical rotor magnet to a degree of

temporary attachment, and by infiltrating the adhesive into a gap between the rotor magnet and the rotor shaft by vacuum impregnation to accomplish the adhesion.

[0039]

Concretely speaking, a method of joining a rotor shaft, having a pinion and a shaft formed integrally therewith, into a cylindrical rotor magnet having a hollow portion at a central portion thereof, comprises a first step of press-fitting the rotor shaft having a press-in length t which is in a range of $T/5 \leqq t \leqq T/2$ relative to the height T of the rotor magnet, and a second step of junction by infiltrating the adhesive into a gap between the rotor shaft and the rotor magnet by vacuum impregnation.

[0040]

In the first step, it is an essential requirement that the rotor magnet is not broken and the rotor shaft is not deviated. The securing force, on the other hand, can be adjusted to be not smaller than the specified value of 0.2 kgf by adhering the rotor after the junction. Therefore, the press-in margin of the rotor shaft may be suitably determined relative to the press-in length, and the junction in the first step, i.e., a light press-in, may be effected to a degree of temporary attachment.

[0041]

When the rotor magnet of the invention is a bonded magnet, the mechanical strength is essentially small. It is therefore desired to increase the mechanical strength by coating the bonded magnet with a metallic plated film or with an organic film. The coating with a film is further effective in preventing the powder from falling off the rotor.

[0042]

When a metallic film is to be plated, it is desired to non-electrolytically plate an Ni-P type film in a manner that the thickness of plating on the inner periphery of the cylinder becomes the same as that on the outer periphery. It is desired that the thickness of the plating is not smaller

than 10 μm to improve the mechanical strength. In the case of the organic film, the object is achieved by any one of spray-coating of an epoxy resin, vacuum evaporation of a polyparaxylylene or electro-deposition coating. It is desired that the coated film has a thickness of not smaller than 20 μm for improving the mechanical strength.

[0043]

In the vacuum impregnation of adhesive in the second step, the adhesive infiltrates without any problem if the adhesion margin (b-c) which is a gap between the rotor shaft and the rotor magnet is not smaller than 2 μm. Further, the adhesive is not removed in the step of washing with an organic solvent if the length (T-t) of the adhered portion is not smaller than 50 μm. It is desired that the adhesive is a thermosetting epoxy resin having a low viscosity and a long pot life, at normal temperature, from the standpoint of adhering force and workability.

[0044]

Upon being thus joined, the rotor shaft is secured with a force of not smaller than 0.2 kgf, and there is provided a stable rotor with no dispersion in the securing force.

[0045]

In the vacuum impregnation of adhesive for the rotors that are temporarily joined, from 10,000 to 1,000,000 rotors can be treated, batchwise, at one time, and can be produced at a low cost.

[0046]

[Embodiments]

The invention will now be described by way of embodiments.

[0047]

(Embodiment 1)

Fig. 1 is a sectional view illustrating a rotor for an electronic timepiece according to an embodiment 1 of the present invention. Fig. 1(a) illustrates a rotor for an

electronic timepiece after the rotor shaft is joined to the rotor magnet, and Fig. 1(b) illustrates the rotor magnet before being joined. In Fig. 1, reference numeral 11 denotes a sintered magnet of the Sm_2Co_{17} type, 12 denotes a rotor shaft made of a JIS SK4 material having a pinion and a shaft integrally formed therewith, and 14 denotes an adhesive. Further, T denotes the height of the rotor magnet, t denotes a press-in length, b denotes an inner diameter of the rotor magnet, a denotes an outer diameter of the press-in portion of the rotor shaft (a > b), and (a-b) is a press-in margin. Further, c denotes an outer diameter of the adhered portion of the rotor shaft, and d denotes an outer diameter of the rotor magnet.

[0048]

The rotor magnet used in this embodiment will now be described in detail. First, the rotor magnet is a sintered magnet of the Sm_2Co_{17} type, and measures ϕ1250 μm (outer diameter) x ϕ350 μm (inner diameter) x 500 μm (thickness).

[0049]

Next, the rotor shafts of various sizes described below are joined. Namely, there are provided rotor shafts 12 having press-in lengths t shown in Fig. 1 of 50 μm, 70 μm, 100 μm, 200 μm, 300 μm, 400 μm, 420 μm and 450 μm, having outer diameters a of the press-in portions of the rotor shafts of ϕ350 μm, ϕ355 μm and ϕ360 μm, and having an outer diameter c of the adhered portions of the rotor shafts of ϕ330 μm.

In the first step, the rotor shafts 12 are press-fitted into the hollow portions of the above rotor magnets so as to come in contact with the whole inner peripheries.

[0050]

Table 1 shows the results of when the above rotor shafts are joined to the rotor magnets by press-in and adhesion. When the press-in length t of the rotor shaft is smaller than 100 μm, the shaft is deviated. When the press-in margin of

the press-in portion of the rotor shaft is 0 μm and when the press-in length is smaller than 200 μm, some of the rotor shafts are pulled out while being handled in the step preceding the second step of adhesion. When the outer diameter a of the press-in portion of the rotor shaft is ϕ360 μm (press-in margin is 10 μm), some rotor magnets are cracked due to the press-in. In other cases, the rotor shafts are temporarily press-fitted without being deviated and without causing the rotor magnets to be broken.

[0051]

[Table 1]

Secured state or securing forces after the first step (unit; kgf).

a-b \ t	50	70	100	200	300	400	420	450
0	I	I	II	II	0.02	0.04	0.04	0.05
5	I	I	0.02	0.05	0.07	0.13	0.15	0.16
10	I	I	III	III	III	III	III	III

I: shaft is deviated   II: shaft is pulled out

III: cracked

unit of t and (a-b); μm

[0052]

In the second step, about 10,000 rotors are temporarily press-fitted under the conditions of the first step and are introduced into a one-liter beaker, and are put into a vacuum container where the atmosphere is evacuated down to 0.1 Torr. Then, a thermosetting liquid epoxy resin is poured into a beaker, and the vacuum container is opened to the air. Then, the beaker may be put into a pressurizing container where the pressure may be elevated to 3 kg/cm^2 to 5 kg/cm^2. Thereafter, the beaker is transferred into a stainless steel mesh container, where almost all of the epoxy resin is washed away, so that undesired epoxy resin will not adhere onto the rotors, using ethanol. Here, the washing can be accomplished within a

short period of time if ultrasonic waves are used. Then, curing is conducted at 180°C for 3 hours to complete the adhesion and securing of the rotor shaft and the rotor magnet.

[0053]

Table 2 shows the results when the above rotor shafts are joined to the rotor magnets by press-in and adhesion. The securing forces are not smaller than 0.2 kgf when the press-in length t is from 100 μm to 400 μm. When the press-in length t exceeds 400 μm, however, the securing force becomes smaller than 0.2 kgf, and the effect of adhesion decreases.

[0054]

[Table 2]

Secured state or securing forces after the second step (unit; kgf).

a-b \ t	50	70	100	200	300	400	420	450
0	I	I	II	II	0.18	0.15	0.09	0.07
5	I	I	0.25	0.85	0.84	0.54	0.17	0.17
10	I	I	III	III	III	III	III	III

I: shaft is deviated   II: shaft is pulled out

III: cracked

unit of t and (a-b); μm

[0055]

Tables 1 and 2 show the results when the rotor shafts are joined to the rotor magnets by press-in and adhesion. In the case of the rotors having a press-in length t in a range of $T/5 \leqq t \leqq 4T/5$ with respect to the height T of the rotor magnet, there do not occur defects such as cracks in the rotor magnet, deviation of shaft during the press-in or pull out of the rotor shaft while being handled, and there is obtained a rotor for an electronic timepiece having good characteristics.

Namely, in this embodiment, T = 500 μm and, hence, T/5 = 100 μm and 4T/5 = 400 μm. Accordingly, the obtained rotors for electronic timepieces have favorable characteristics in a

range surrounded by bold lines in Table 2, i.e., in a range of $T/5 \leqq t \leqq 4T/5$.

[0056]

This embodiment uses sintered magnets of the Sm_2Co_{17} type. The same effect is obtained even with sintered magnets of the $SmCo_5$ type or the NdFeB type.

[0057]

(Embodiment 2)

Next, another embodiment of the invention will be described. Fig. 2 is a sectional view illustrating a rotor for an electronic timepiece according to another embodiment of the present invention. Fig. 2(a) illustrates a rotor for an electronic timepiece after the rotor shaft is joined to the rotor magnet, and Fig. 2(b) illustrates the rotor magnet of before being joined. In Fig. 2, reference numeral 21 denotes a bonded magnet of the Sm_2Co_{17} type, 23 denotes a metallic plated film, 22 denotes a rotor shaft made of a JIS SK4 material having a pinion and a shaft integrally formed therewith, and 14 denotes an adhesive. Further, T denotes the height of the rotor magnet after being plated, t denotes a press-in length, b denotes an inner diameter of the rotor magnet after being plated, a denotes an outer diameter of the press-in portion of the rotor shaft (a > b), and (a-b) is a press-in margin. Further, c denotes an outer diameter of the adhered portion of the rotor shaft, and d denotes an outer diameter of the rotor magnet.

[0058]

The rotor magnet used in this embodiment will now be described in detail. First, the rotor magnet is a bonded magnet of the Sm_2Co_{17} type using an epoxy type binder, and measures ϕ1250 μm (outer diameter) x ϕ350 μm (inner diameter) x 500 μm (thickness). Further, the metallic plated film has a thickness of 15 μm when it is a non-electrolytically plated Ni-P film. In the case of this embodiment, therefore, $T = 500 + 15 \times 2 = 530$ μm.

[0059]

Next, the rotor shafts of various sizes described below are joined. Namely, there are provided rotor shafts 22 having press-in lengths t shown in Fig. 2 of 70 μm, 90 μm, 120 μm, 220 μm, 320 μm, 420 μm, 440 μm and 470 μm, having outer diameters a of the press-in portions of the rotor shafts of φ320 μm, φ325 μm and φ330 μm relative to the press-in lengths t, and having an outer diameter c of the adhered portions of the rotor shafts of φ300 μm.

In the first step, the rotor shafts 22 are press-fitted into the hollow portions of the above rotor magnets 21 so as to come in contact with the whole inner peripheries.

[0060]

Table 3 shows the results of when the above rotor shafts are joined to the rotor magnets by press-in and adhesion.

When the press-in length t of the rotor shaft is smaller than 100 μm, the shaft is deviated. When the press-in margin (a-b) of the press-in portion of the rotor shaft is 0 μm and when the press-in length is smaller than 320 μm, some of the rotor shafts 22 are pulled out while being handled in the step preceding the second step of adhesion. When the outer diameter a of the press-in portion of the rotor shaft is φ330 μm (press-in margin is 10 μm), some rotor magnets are cracked due to the press-in. In other cases, the rotor shafts are temporarily press-fitted without being deviated and without causing the rotor magnets to be broken.

[0061]

[Table 3]

Secured state or securing forces after the first step (unit; kgf).

t / a-b	70	90	120	220	320	420	440	470
0	I	I	II	II	II	0.03	0.05	0.05
5	I	I	0.04	0.05	0.09	0.13	0.14	0.15
10	I	I	III	III	III	III	III	III

I: shaft is deviated II: shaft is pulled out
III: cracked

unit of t and (a-b); μm

[0062]

In the second step, about 10,000 rotors, that are temporarily press-fitted under the conditions of the first step, are introduced into a one-liter beaker, and are put into a vacuum container where the atmosphere is evacuated down to 0.1 Torr. Then, a thermosetting liquid epoxy resin is poured into a beaker, and the vacuum container is opened to the air. Then, the beaker may be put into a pressurizing container where the pressure may be elevated to 3 to 5 kg/cm^2. Thereafter, the beaker is transferred into a stainless steel mesh container where almost all of the epoxy resin is washed away, so that undesired epoxy resin will not adhere onto the rotors, using ethanol. Here, the washing can be accomplished within a short period of time if ultrasonic waves are used. Then, curing is conducted at 180°C for 3 hours to complete the adhesion and securing of the rotor shaft and the rotor magnet.

[0063]

Table 4 shows the results of when the above rotor shafts are joined to the rotor magnets by press-in and adhesion. The securing forces are not smaller than 0.2 kgf when the press-in length t is from 100 μm to 400 μm. When the press-in length t exceeds 400 μm, however, the securing force becomes smaller than 0.2 kgf, and the effect of adhesion decreases.

[0064]

[Table 4]

Secured state or securing forces after the second step (unit; kgf).

t / a-b	70	90	120	220	320	420	440	470
0	I	I	II	II	II	0.14	0.10	0.08
5	I	I	0.28	0.78	0.76	0.45	0.16	0.17
10	I	I	III	III	III	III	III	III

I: shaft is deviated   II: shaft is pulled out
III: cracked

unit of t and (a-b); μm

[0065]

Tables 3 and 4 show the results when the rotor shafts are joined to the rotor magnets by press-in and adhesion. In the case of the rotors having a press-in length t in a range of $T/5 \leqq t \leqq 4T/5$ with respect to the height T of the rotor magnet, there do not occur such defects as cracks on the rotor magnet, deviation of shaft during the press-in or pull out of the rotor shaft while being handled, and there are obtained rotors for electronic timepieces having good characteristics.

Namely, in this embodiment, T = 530 μm and, hence, T/5 = 106 μm and 4T/5 = 424 μm. Accordingly, there are obtained rotors for electronic timepieces having favorable characteristics in a range surrounded by bold lines in Table 4, i.e., in a range of $T/5 \leqq t \leqq 4T/5$.

[0066]

This embodiment uses bonded magnets of the Sm_2Co_{17} type. The same effect is obtained even with bonded magnets of the $SmCo_5$ type or the NdFeB type.

[0067]

The same effect is obtained even by coating the rotor magnet with an organic high molecular polyparaxylyene film maintaining a thickness of 25 μm instead of plating the rotor magnet with a metal.

[0068]

As will be understood from Examples 1 and 2, the invention can be utilized even by using, as the rotor magnet for an electronic timepiece, either a sintered magnet or a

bonded magnet.

[0069]

Accordingly, the invention makes it possible to obtain rotors for electronic timepieces, having favorable characteristics, free from such defects as cracks on the rotor magnet, deviation of shaft during the press-in or pull out of the rotor shaft while being handled.

[0070]

[Effects of the Invention]

As described above, the invention produces a rotor for an electronic timepiece in a manner as described below.

[0071]

That is, a rotor for an electronic timepiece is produced by a method of joining a rotor shaft having a pinion and a shaft formed integrally therewith into a cylindrical rotor magnet having a hollow portion at a central portion thereof, comprising a first step of press-fitting the rotor shaft into the rotor magnet, the rotor shaft having a press-in length t which is in a range of $T/5 \leqq t \leqq T/2$ relative to the height T of the rotor magnet, and a second step of junction of infiltrating the adhesive into gaps between the rotor shaft and the rotor magnet using vacuum impregnation.

[0072]

Therefore, there is obtained a rotor for an electronic timepiece without causing the rotor magnet to be broken yet having a practical securing force.

Namely, the invention makes it possible to obtain rotors for electronic timepieces having favorable characteristics and free from defects such as cracks on the rotor magnet, deviation of shaft during the press-in or pull out of the rotor shaft while being handled.

[0073]

The invention, therefore, makes it possible to provide a structure for securing the rotor shaft to the rotor magnet without cracking the rotor magnet at the time of junction yet producing a sufficient force for securing the rotor shaft, and

a method of producing the same.

The invention further makes possible to produce a reliable rotor at a decreased cost.

[BRIEF DESCRIPTION OF THE DRAWINGS]

[Fig. 1] is a sectional view of a rotor for an electronic timepiece according to an embodiment of the present invention.

[Fig. 2] is a sectional view of the rotor for an electronic timepiece according to another embodiment of the present invention.

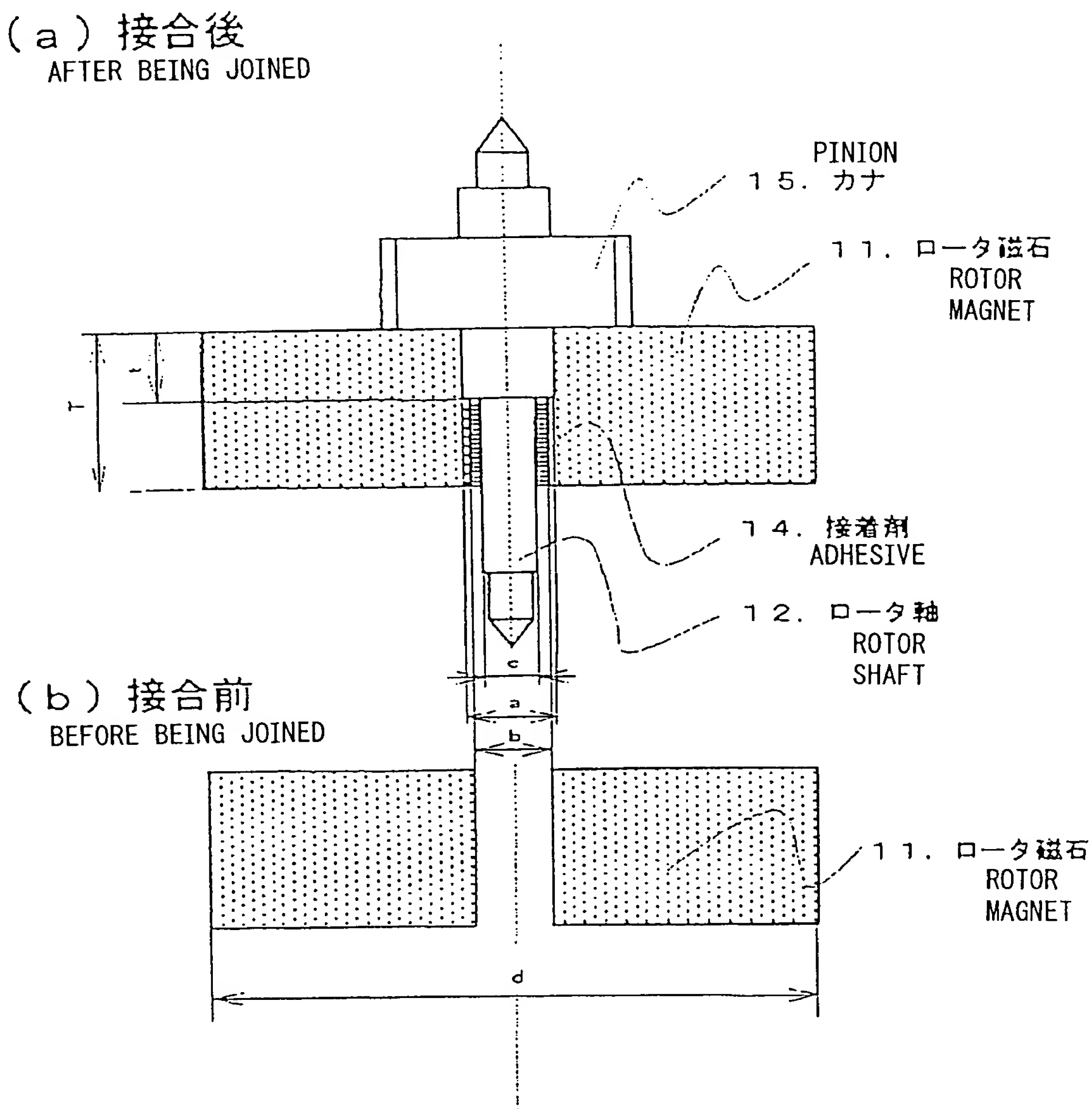
[Fig. 3] is a sectional view of a rotor for an electronic timepiece according to a prior art.

[Fig. 4] is a sectional view along A-A'.

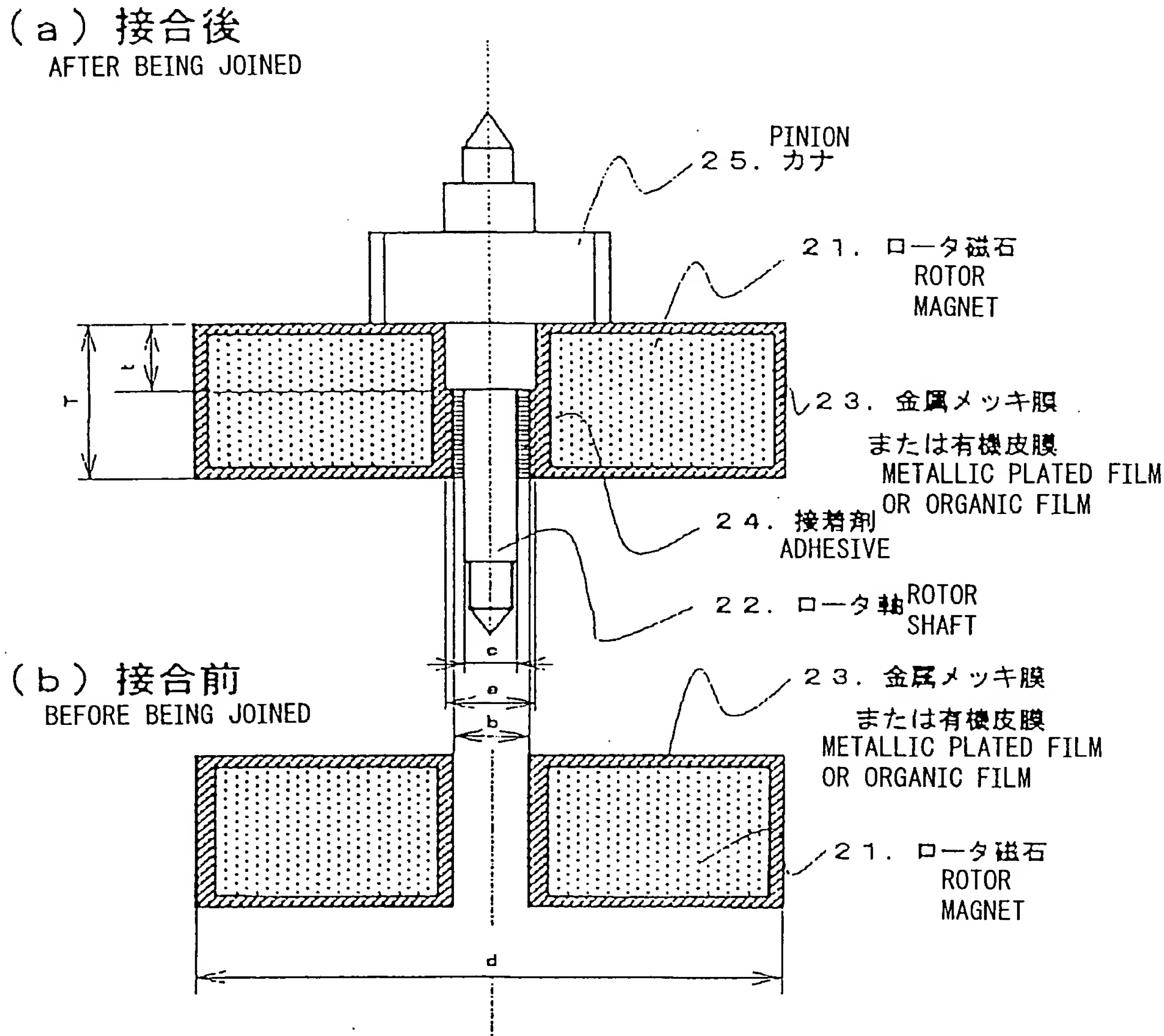
[Description of Reference Numerals]

11, 21, 31 - rotor magnets
12, 22, 32 - rotor shafts
14, 24 - adhesives
15, 25, 33 - pinions
23 - metallic plated film or organic film
T - height of rotor magnet (inclusive of metallic plated film or organic film when it is formed)
t - press-in length
a - outer diameter of press-in portion of rotor shaft
b - inner diameter of rotor magnet (inclusive of metallic plated film or organic film when it is formed)
c - outer diameter of adhere portion of rotor magnet
d - outer diameter of rotor magnet (inclusive of metallic plated film or organic film when it is formed)

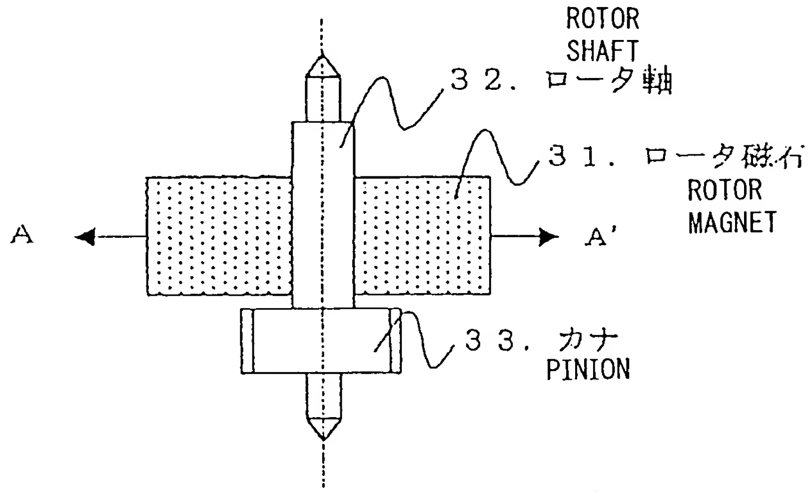
【書類名】　図面
[NAME OF DOCUMENT]　DRAWINGS
【図１】
[FIG. 1]



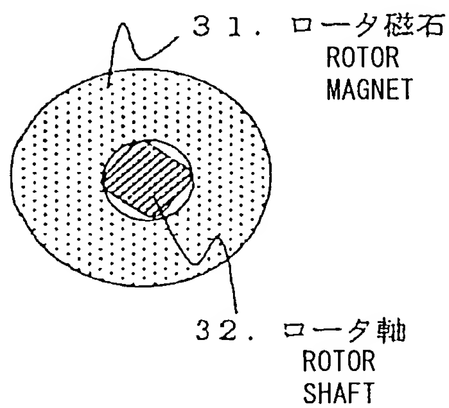
【図２】
[FIG. 2]


（ａ）接合後
AFTER BEING JOINED
PINION
２５．カナ
２１．ロータ磁石
ROTOR
MAGNET
２３．金属メッキ膜
または有機皮膜
METALLIC PLATED FILM
OR ORGANIC FILM
２４．接着剤
ADHESIVE
２２．ロータ軸
ROTOR
SHAFT
T
c
a
b
（ｂ）接合前
BEFORE BEING JOINED
２３．金属メッキ膜
または有機皮膜
METALLIC PLATED FILM
OR ORGANIC FILM
２１．ロータ磁石
ROTOR
MAGNET
d

【図３】
[FIG. 3]



【図４】
[FIG. 4]



[NAME OF DOCUMENT] ABSTRACT

[Abstract]

[Problem] To provide a production method of joining a rotor shaft to a rotor magnet without causing the rotor magnet to be broken yet producing a practicable securing force, and to provide a rotor produced by this method at a low cost.

[Means for Solution] A method of joining a rotor shaft having a pinion and a shaft formed integrally therewith into a cylindrical rotor magnet having a hollow portion at a central portion thereof, comprising a first step of press-fitting the rotor shaft having a press-in length t which is in a range of $T/5 \leqq t \leqq T/2$ relative to the height T of the rotor magnet, and a second step of junction by infiltrating the adhesive into gaps between the rotor shaft and the rotor magnet using vacuum impregnation. This method makes it possible to obtain a practicable securing force without breaking the rotor magnet and to produce a rotor for an electronic timepiece at a low cost.

[Selected Drawing] Fig. 1